Sustainable Technologies on the Horizon

Fort Carson Sustainability Conference

November 9, 2005

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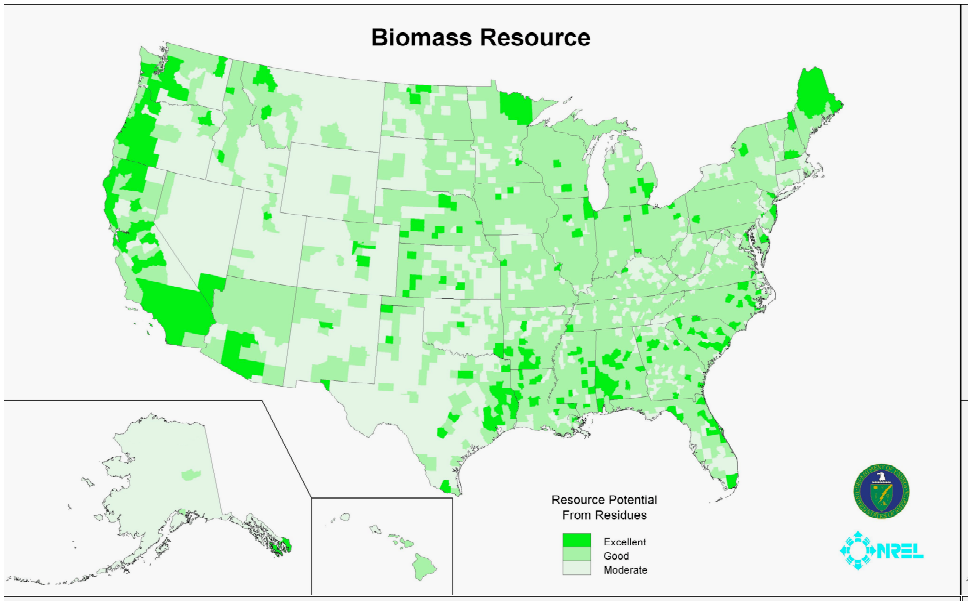
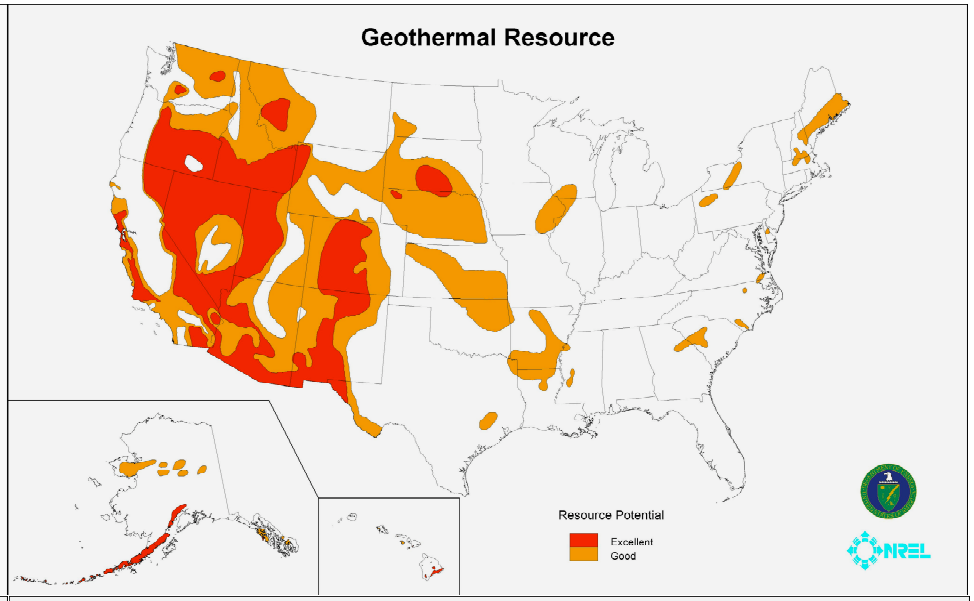
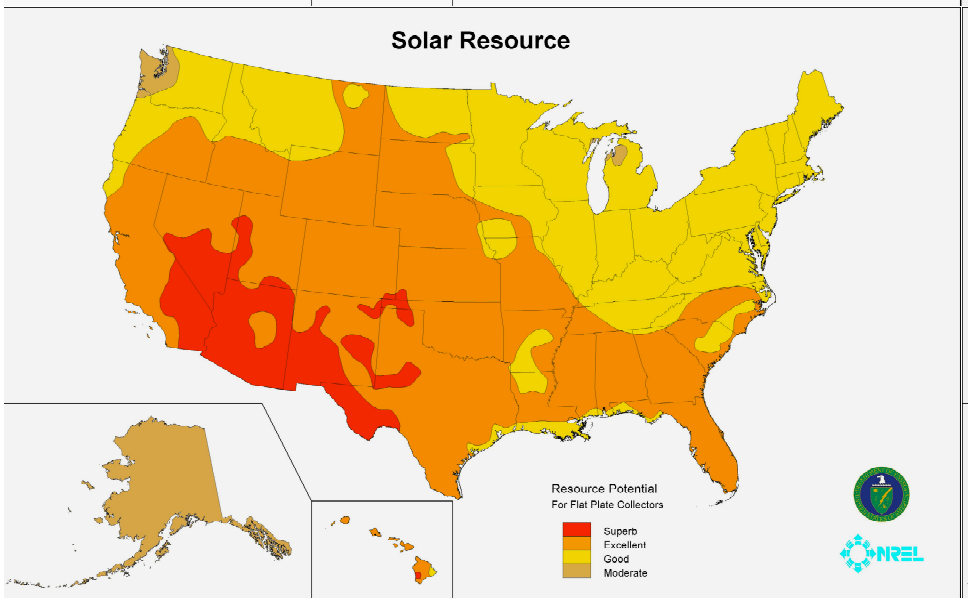
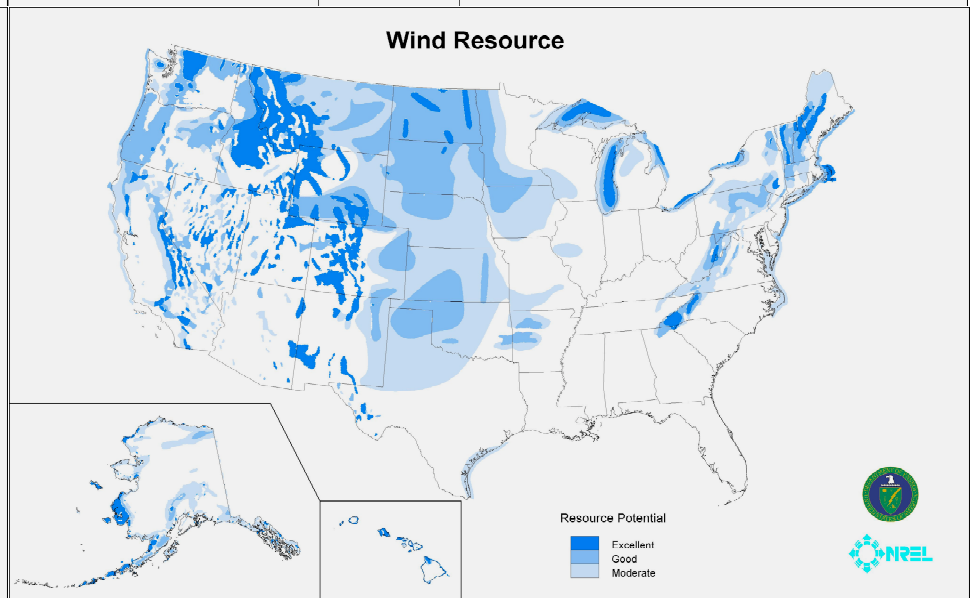
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Renewable Energy Availability









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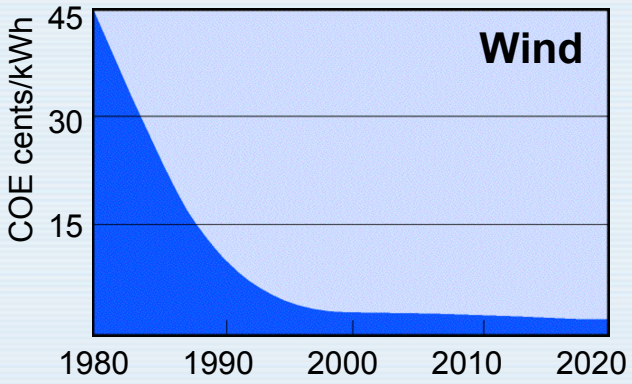
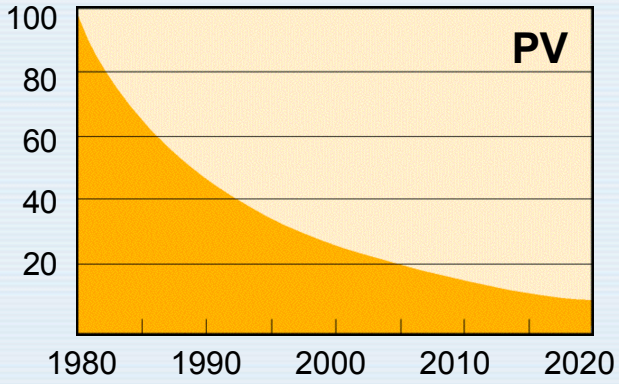
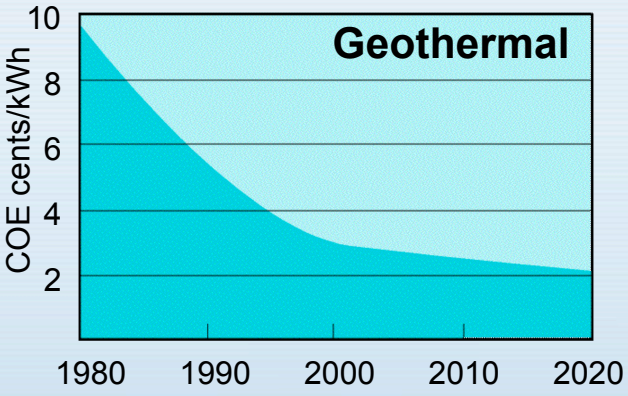
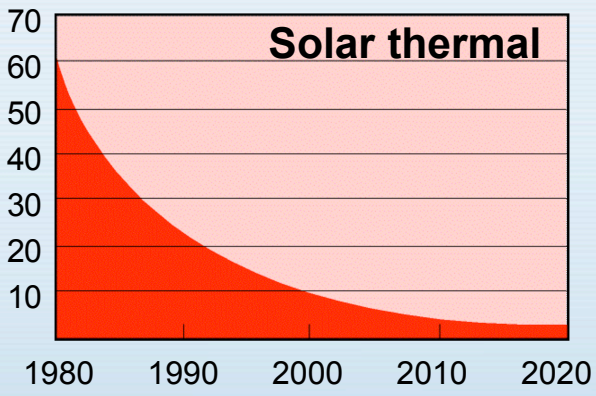
Renewable Energy Cost Trends

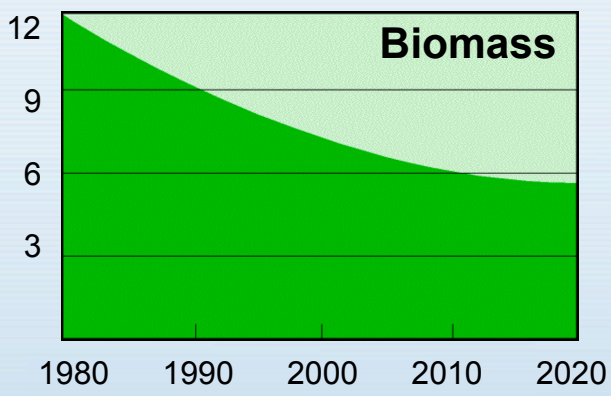
Levelized cents/kWh in constant $2000[1]











Source: NREL Energy Analysis Office
Updated: June 2002

Photovoltaics (PV) Basics

- PV converts sunlight directly to electricity

- Building-Integrated Photovoltaics (BIPV) - Systems where PV elements are integral part of the building & replace part of building skin costs

- Turnkey Cost = $6-$20/watt. Cost considerations:
  - Resource quality
  - Type of PV panel
  - Significant costs (50% or greater) for Balance-of-System (BOS) components & installation
  - Additional cost for back-up battery
  - Available incentives (see http://www.dsireusa.org/)
  - Cost of alternatives (utility rates, diesel, utility line extension, etc)

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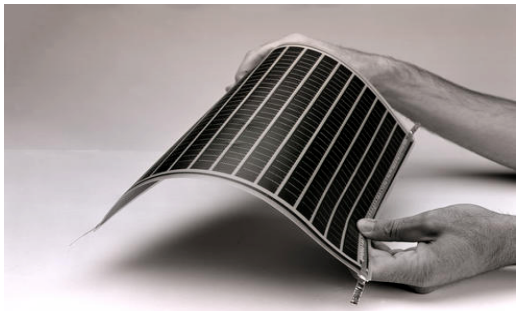
PV/BIPV Examples

PV Lighting
PJKK Federal Building, HI

BIPV, Mauna Lani Hotel

BIPV
4 Times Square, NY City
(Broadway & 42nd Street)



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Naval Air Station N. Island

924 kW PV system providing shaded parking for 444 vehicles.

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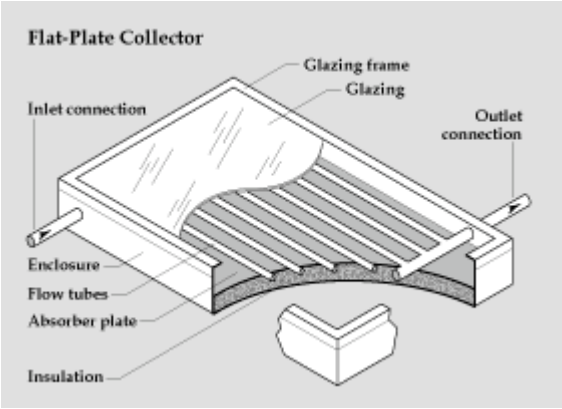
Solar Hot Water (SHW)

Low temperature system

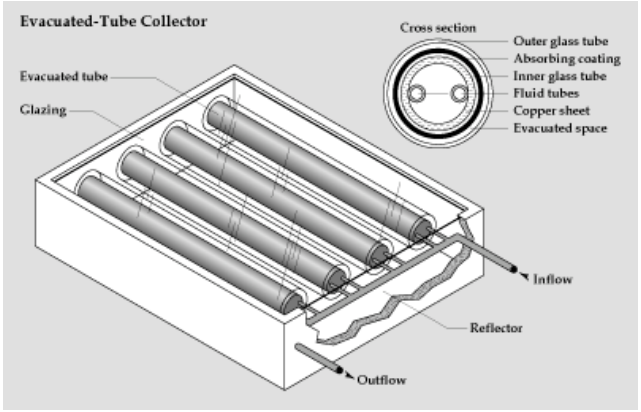
- Unglazed mats
- Glazed and insulated



Residential hot water
Swimming pools

Medium temperature system

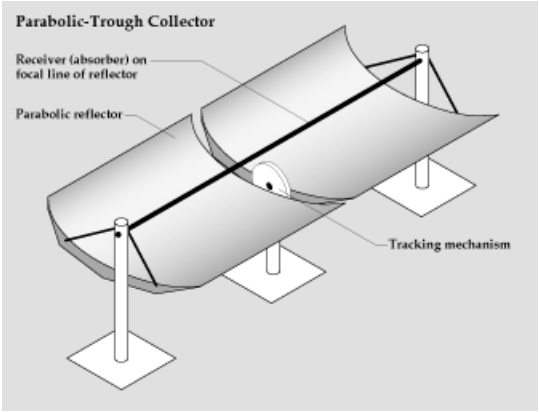
- Evacuated tubes



Cafeterias
Laundries

High temperature system

- Parabolic Concentrators



Industrial processes
Electrical generation

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Federal SHW Examples

USCG Kia'i Kai Hale Housing Area, Honolulu, HI

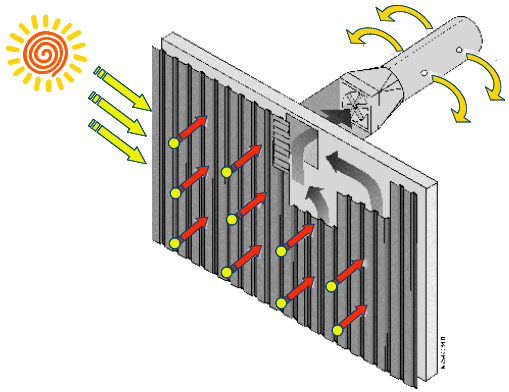
Barnes Field House, Fort Huachuca, AZ

EPA Edison, New Jersey

Phoenix Federal Correctional Institution
http://www.eere.energy.gov/femp/pdfs/33211.pdf

"Solar Wall"

- **High ventilation requirements**
- **New construction**
- **Retrofit - available south wall area with fan intake**



Concentrating Solar Power

- Concentrating Solar Power (CSP) Operation
  - Concentrates & focuses sunlight onto receiver mounted at system's focal point
  - Receiver absorbs sunlight and heats working fluid
  - Working fluid used in engine to produce electricity

- Requires a very good, direct solar resource

- Technologies
  - Parabolic Troughs
  - Dish/Engine Systems
  - Power Towers

- Western Governor's Association (WGA) - 30GW of clean energy by 2015 goal, including 1 GW CSP

CSP

Dish Stirling

Trough
Mojave Desert, California

Solar One Power Tower
Daggett, California

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Research Focus in Solar

- Higher efficiency devices
- New nanomaterials applications
- Cheaper material
- Advanced manufacturing techniques & lower production costs
- Concentrating PV
- Bottom line – reduce ¢/kWh

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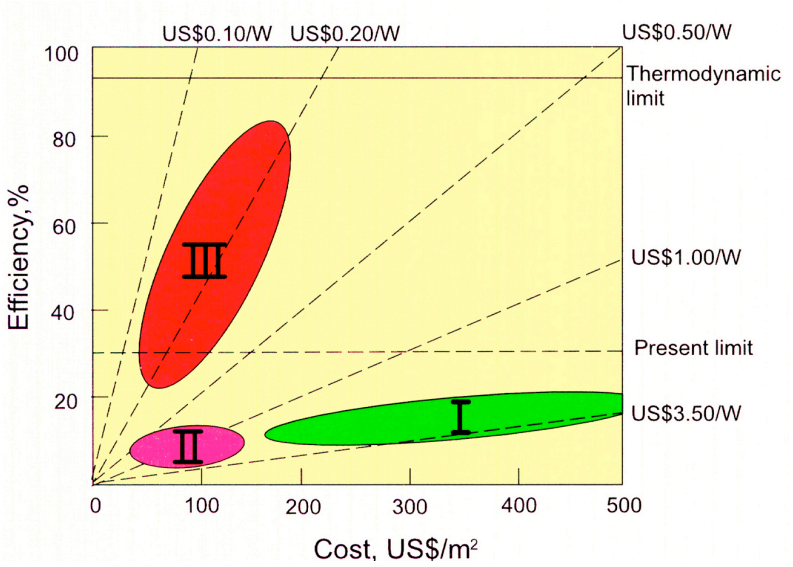
Advanced "3rd-Generation" Solar

I. 1st Generation – Crystalline
   - Expensive & low efficiency

II. 2nd Generation (Polycrystalline Thin Film)
   - Cheaper, but still low efficiency

III. 3rd Generation
   - Multi-junction cells (>30% efficiency)
   - Quantum dots (>60% efficiency)



Region III indicates efficiencies higher than previous theoretical limits, at lower costs, made possible by nanostructures such as quantum dots

Wind Power

Resource:

Wind power is created by the uneven heating of the earth's surface by the sun.

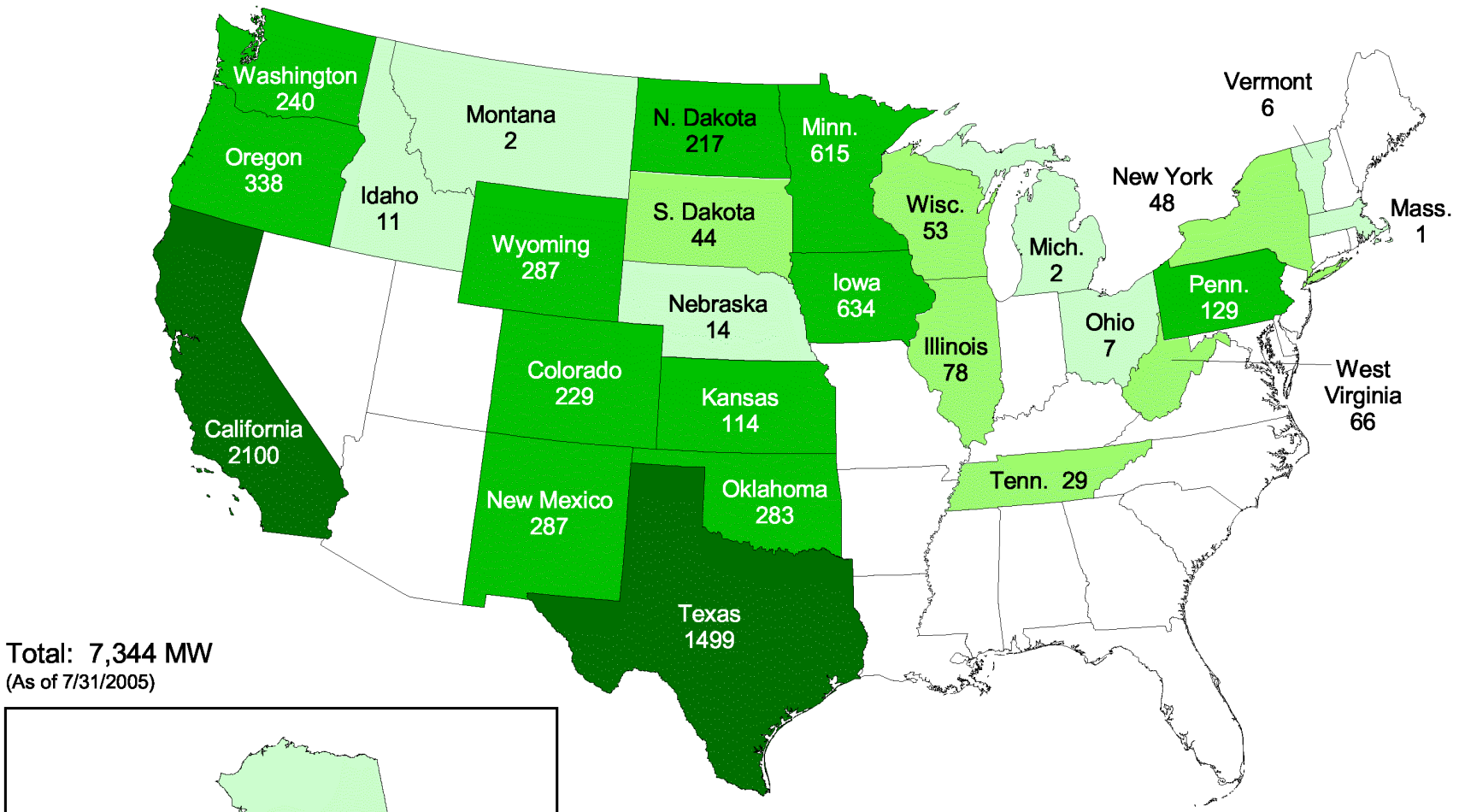
Energy production is proportional to wind speed cubed (V^3)

-Wind speed increases with height

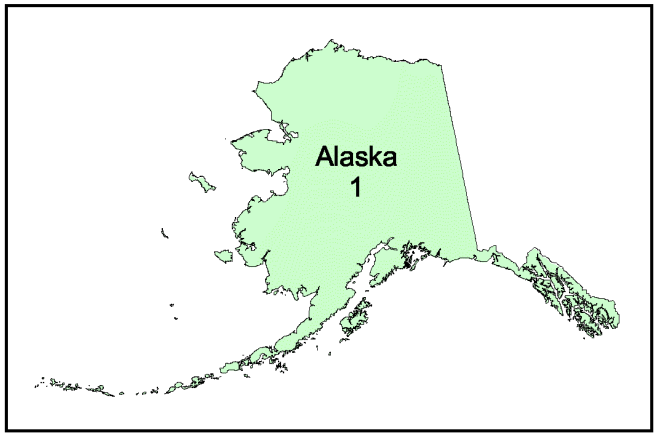
Technologies:

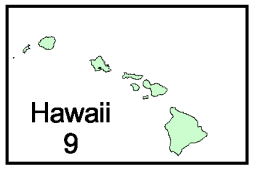
- Small turbines (100 kW and smaller)
- Large turbines (100 kW to 5 MW)

United States - 2005 Installed Wind Power Capacity (MW)



Total: 7,344 MW
(As of 7/31/2005)





Wind Power Capacity
Megawatts (MW)

- 1,000 - 2,100
- 100 - 1,000
- 20 - 100
- 1 - 20

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NREL

24-AUG-2005 1.1.22

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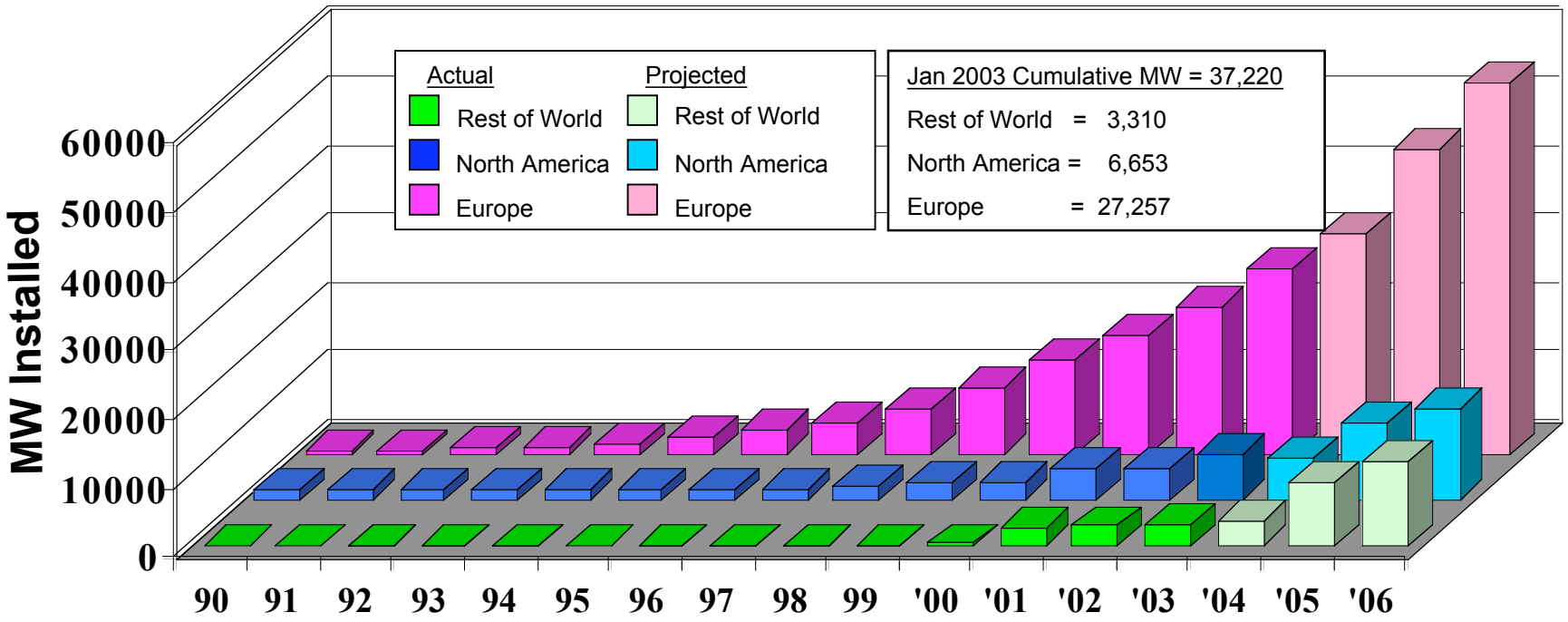
Growth of Wind Energy Capacity Worldwide



Sources: BTM Consult Aps, March 2003
Windpower Monthly, January 2004
*NREL Estimate for 2004

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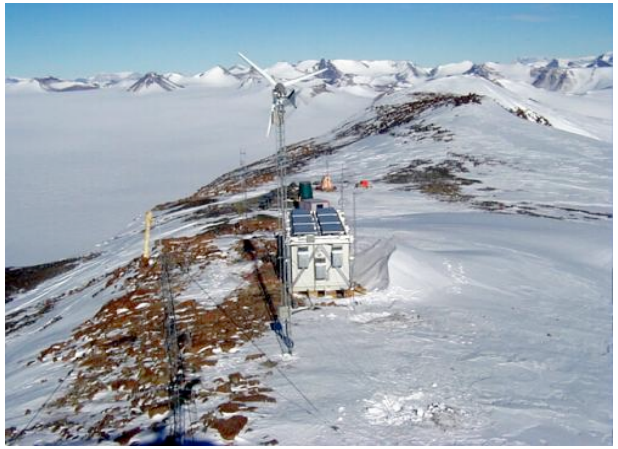
Federal Wind Examples



Research Focus in Wind

- Technology transfer to ocean-based systems
- Low-wind speed turbines (LWST)
- Better aerodynamic blades, new materials
- Advanced power electronics

Biomass Issues/Research

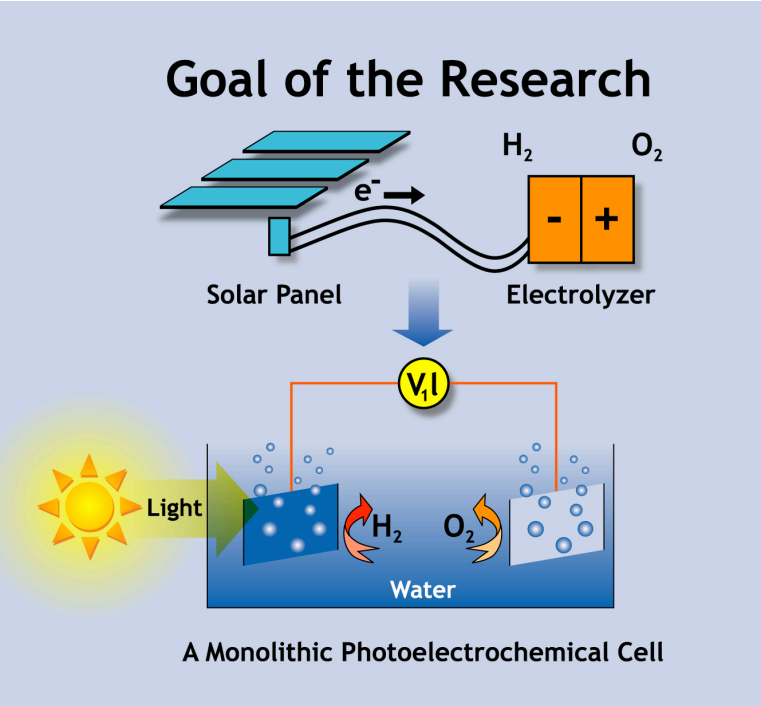
- New feedstocks - advanced energy crops, under-utilized waste

- Feedstock issues
  - Crop production cycle
  - Drying and storage - potential degradation problems
  - Transportation
  - Varying feedstock characteristics

- "Biorefinery Concept"
  - Thermochemical conversion process such as gasification
  - Biochemical conversion process - fermentation of sugars extracted from biomass feedstocks

Hydrogen Research Example

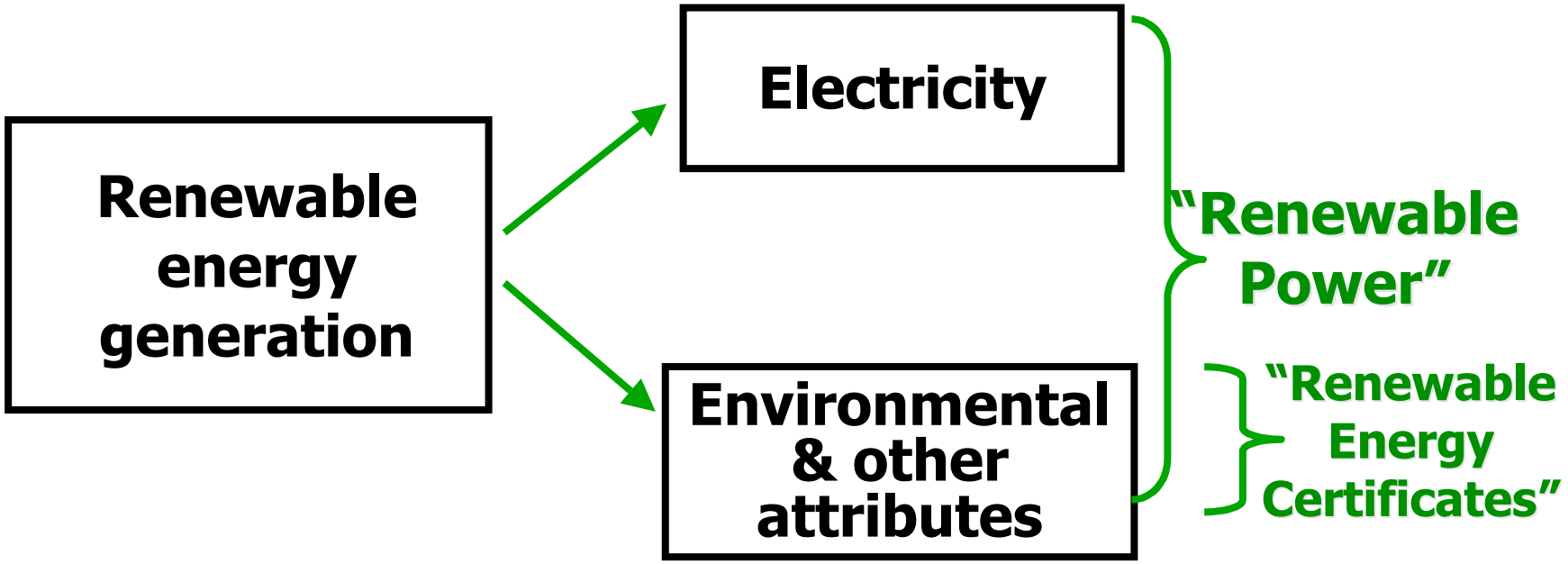
Photoelectrochemical-Based Direct Conversion Systems



- Produce hydrogen directly from water using sunlight
- Combine PV system and an electrolyzer
- Balance of system costs reduced
  - Capital cost of electrolyzer eliminated
- Efficiency 30% higher than separated system

Renewable Power Purchasing Options

- Regulated Utility Green Pricing
- Competitive Electricity Market
- Renewable Energy Certificates (REC)
  - Renewable attributes unbundled from physical, "generic" electricity



Why Use Renewables?

- Volatile energy market – price risk management
- Reduce dependence on fossil fuel imports – "homegrown" energy instead
- Fuel diversity
- Water
- Economic development
- Market transformation
- Lead by example
- Demonstrate environmental stewardship

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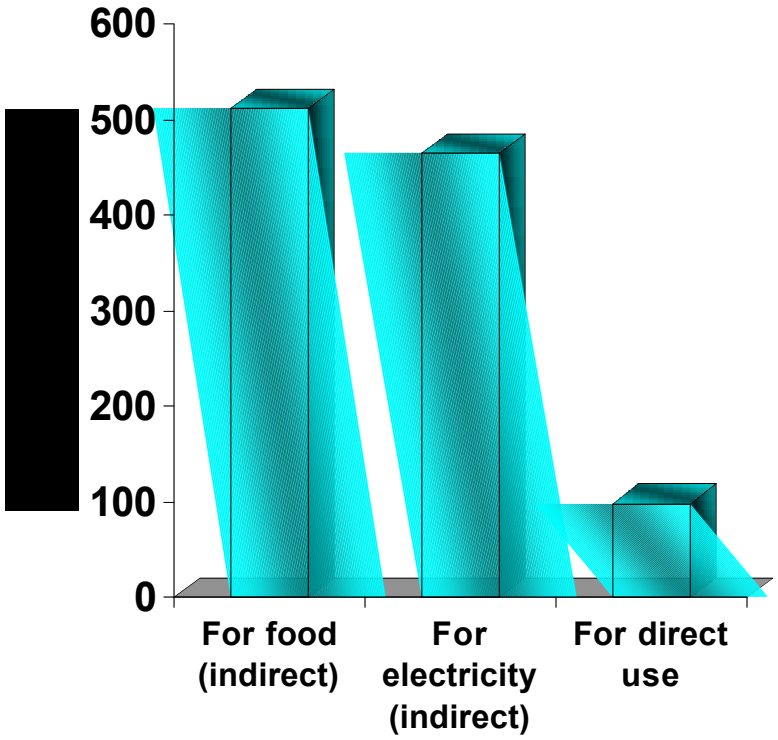
Energy Requires Water

Water used to produce household electricity exceeds direct household water use



GALLONS PER PERSON PER DAY

- 510 for food production
  - includes irrigation and livestock
- 465 to produce household electricity
  - Range: 30 to 600 depending on technology
- 100 direct household use
  - includes bathing, laundry, lawn watering, etc.

Source: derived from Gleick, P. (2002), *World's Water 2002-2003*.

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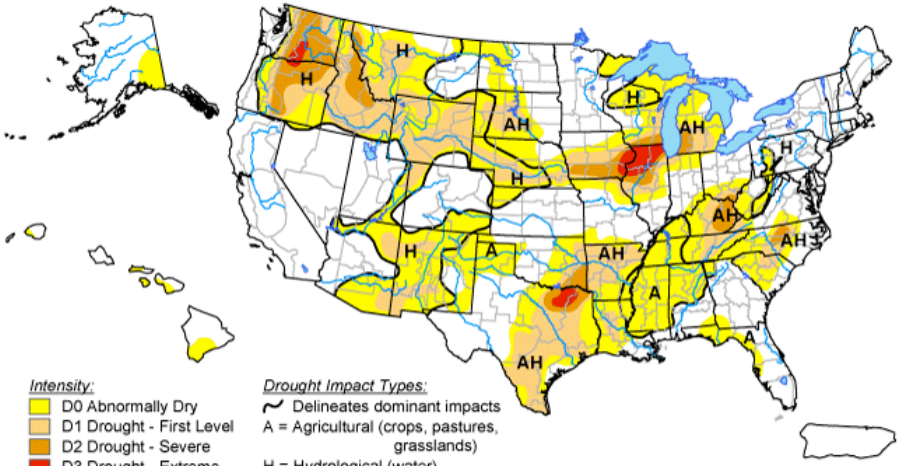
U.S. Drought Monitor

November 1, 2005
Valid 7 a.m. EST



Intensity:
- D0 Abnormally Dry
- D1 Drought - First Level
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:
- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

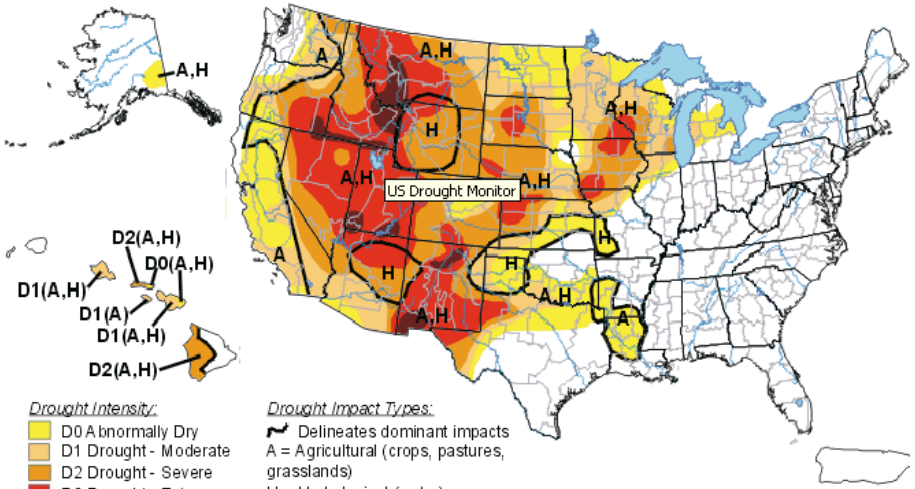
http://drought.unl.edu/dm

USDA National Drought Mitigation Center

Released Thursday, November 3, 2005
Author: R. Heim/L. Love-Brotak, NOAA/NESDIS/NCDC

U.S. Drought Monitor

October 28, 2003
Valid 8 a.m. EST



Drought Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

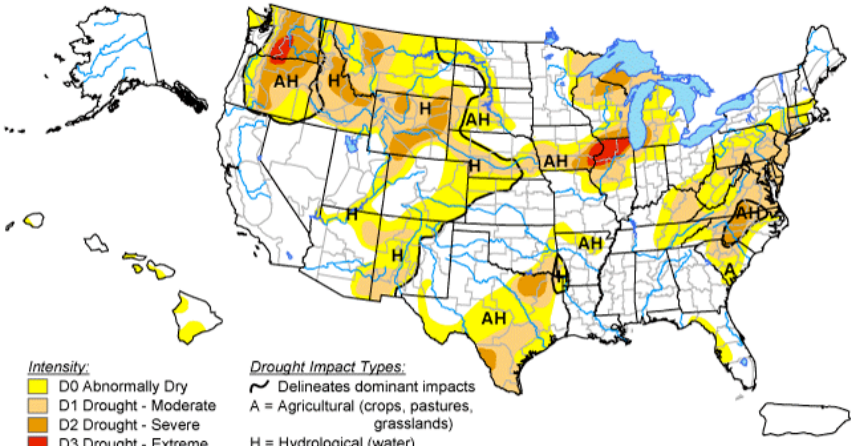
Drought Impact Types:
- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary

USDA National Drought Mitigation Center

U.S. Drought Monitor

October 4, 2005
Valid 8 a.m. EDT



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The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

USDA National Drought Mitigation Center

Released Thursday, October 6, 2005
Author: RichTinker, CPC/NCEP/NWS/NOAA

Humanity's Top Ten Problems for next 50 years

1. **ENERGY**
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

2003	6.3	Billion People
2050	9-10	Billion People

Source: Nobel laureate, Richard Smalley